on p. 51 that the writing of the scribes was sometimes so minute that magnifying glasses were used for reading by the Assyrians, and that short sight "must have been common in the Babylonian schools," is, to say the least, rather fanciful, the only evidence for the statement being a circular crystal object found by Layard at Nineveh, and thought to be a lens, but the use of which is unknown. That there was ever "a monotheistic school" at Erech (p. 262) would, we think, be difficult to prove, and the evidence for "human sacrifice" referred to on p. 103 should surely have been given. It is, no doubt, a consequence of the omission of references that we sometimes come across repetitions in the book, as, for instance, the quotation referring to the Chaldeans and their ships in connection with Eridu on pp. 9 and 183; the suggested identification of Sar-ilu with Israel on pp. 17 and 191, the description of the letter referring to a ferry-boat on pp. 186 and 215, &c. Misprints, too, are not uncommon, as, for example, "the eighteen-hundredth*s* part" (p. 114), "I will *lie* up five shekels of silver" (p. 225), "Emutalum" for "Emutbalum" (p. 211), "weight" for "night" (p. 266), "bears" apparently for "beasts" (p. 52), "cuneiplain" apparently for "plain" (p. 211), and on p. 157 we are told that "Aramaic became the *lingua panca* . . . in the commercial world." Prof. Sayce is probably not to blame for such misprints, for the American editor was doubtless responsible for the correction of the proof-sheets.

ELECTRICAL ORGANS. MUSCLE OR NERVE?

Beiträge zur Physiologie des elektrischen Organes der Zitterrochen (*Torpedo*). By Siegfried Garten. Pp. 116, 4 plates. (Leipzig: Teubner, 1899.)

ALTHOUGH electrical fishes have been the object of scientific curiosity and investigation for nearly 300 years, it is only in the last half of this century that physiologists have realised the great importance, for general physiological problems, of the phenomena presented by these remarkable animals. The discovery and investigation of the electrical phenomena accompanying excitation or activity of all the excitable tissues in the animal body have rendered it of supreme importance to attack the problem and the causation of these electrical changes in the organ, where the "electrical function," so to speak, attains its highest degree of development. It seems probable that electrical organs may be developed by the transformation of many different kinds of tissue. In the greater number of these fishes, however, including that which is the subject of the memoir under consideration (Torpedo), the organ is formed by a transformation of embryonic muscle-fibres, accompanied by a disappearance of the cross-striated contractile material, with a great hypertrophy of the nerve-endings. The electrical discharge of the organ, with an E.M.F. probably amounting to 100 to 200 volts (Gotch) and lasting about 6/1000 of a second, may be excited reflexly or by excitation of the nerve to the organ, or, using strong shocks, by stimulation of the organ itself. The direction of the current in the fish is from ventral to dorsal surface. The electrical organ in the torpedo consists of an array of columns, each column being composed of about 400 transverse discs representing the electromotive elements of the organ. On the ventral surface of each of these discs we find the complicated terminal arborisation or network of a nerve-fibre, embedded in granular protoplasm, and separated from the disc by the remains of the primitive muscle-fibre from which the organ was developed.

We must assume that it is in consequence of these structural arrangements that the excitatory electrical change in the whole organ, instead of passing from one end to the other as a wave, and so giving rise to a diphasic variation of small extent, causes merely a change in one direction, which is summated in proportion to the number of discs in the pile, so producing a monophasic variation of considerable E.M.F. It is evident that we could conceive of each disc as consisting of an inferior part, which is excitable and therefore capable of the chemical changes associated with excitation, and of a superior part, structurally and chemically continuous with the inferior, but incapable of excitation. The question at once arises whether these two parts are represented by nerve and muscle, or whether the chief excitatory change takes place in some of the structures derived from the embryonic muscle-fibre. Is the electrical change an action current of nerve-ending or of muscle?

Du Bois Reymond, for theoretical reasons, supported the latter view, and at the same time laid great stress on a remarkable property of the organ. He found that the electrical conductivity of the organ was greater for homodromous currents, *i.e.* those in the direction of the discharge of the organ, than for heterodromous. It was shown later by Gotch that this irreciprocal conductivity is only apparent, Du Bois Reymond's results being due to the fact that, in measuring the current passing through the organ, he was measuring the algebraic sum of the battery current and the current excited in the organ itself. Naturally, therefore, the homodromous current was greater than the heterodromous.

Gotch has also drawn attention to the fact that in the electrical organ we have an opportunity of deciding the nature of the demarcation-current consequent on injury. Since in this organ the demarcation-current is always in the same direction as the excitatory-current, whatever may be the position of the injury, he concludes that the demarcation-current or current of rest is really in all cases an action-current due to the continued stimulation at the seat of injury.

On these three questions, but especially with regard to the nervous or muscular nature of the excitable tissue, additional evidence is furnished by Garten, whose research is devoted chiefly to the elucidation of three points—the effect of nerve-section and subsequent degeneration on the direct excitability of the electrical organ; the effect of drugs, such as curare, which are direct poisons for nerve-endings; and the action of veratrin as a specific muscular poison.

The results of these experiments are a strong confirmation of the views put forward by Gotch. During the first eight days after section of the nerves, the organs can be excited either directly or indirectly; from the eighth to the eighteenth day after section, the organ can be excited to discharge, but the shocks are weaker than normal. After the nineteenth day, however, no response is obtained to stimulation either of the nerve or of the electrical organ itself. Thus the irritability of the organ disappears with that of the nerve, whereas a muscle is excitable long after the degeneration of its motor nerve with end-plates is complete. It may be mentioned that the organ-current, or current of rest, and the irreciprocal conductivity diminish during the period of lowered irritability of the organ, and are absolutely abolished after the nineteenth day, thus pointing to the excitatory nature of both these sets of phenomena.

The experiments on the action of curare are less satisfactory, owing to the enormous doses (1 grm. for a fish of 1200 grms.) which are necessary to paralyse the indirect excitability of the electrical organs. Since in these large doses the curare excites central discharges, it is necessary to cut all the electrical nerves to prevent paralysis by fatigue. In this case, however, with a sufficient dose of curare, direct and indirect excitability are abolished simultaneously. The same interdependence of direct and indirect excitability is observed in paralysis by fatigue, in marked contrast to the behaviour of voluntary muscle, where a muscle on direct stimulation gives a practically normal contraction after complete fatigue by stimulation of its nerve.

Veratrin, which causes a marked prolongation of the excitatory change in skeletal muscle, was found by Garten to produce a somewhat similar effect on the electrical discharge of the torpedo. This drug, however, diminishes and very rapidly abolishes the direct and indirect excitability of the electrical organ, and no proof is afforded that the prolonged response may not be due to the state of artificial "fatigue" produced by the drug, or that it is in any way specific. Waller's experiments have shown that veratrin has practically no action on the nerve, and although Garten quotes certain of his own experiments which appear to indicate an action of this drug on non-medullated nerve, the strength of the solution employed must be regarded as too great for the demonstration of the specific action of the drug.

We cannot, therefore, regard the experiments with veratrin as detracting in any way from the support afforded to the nerve-ending theory of excitation by the results of nerve-section. It is remarkable that a change which, as the current of action in nerve, needs all the appliances of a well-fitted laboratory for its demonstration, should, by a mere subdivision of the fibrils and their enclosure in compartments separated by non-excitable partitions, be able to produce the strong shocks of high intensity which characterise the discharge of the whole organ. No better demonstration could be afforded of the futility of those hypotheses which would explain the passage of the nerve-impulse as a mere propagated polarisation, and would deny any energy-producing changes in the axis-cylinder itself. The absence of fatigue in medullated nerve does not imply absence of chemical change, but merely equivalence of disintegration and reintegration, an equivalence probably connected, as Waller has suggested, with the presence of a medullary sheath. E. H. S.

FLUORINE.

Le Fluor et ses Composés. Par M. Henri Moissan. Pp. xii + 396. (Paris: G. Steinheil, 1900).

THERE could scarcely be a greater contrast than that between the gaseous substances most recently added to our list of elements; fluorine on the one hand, argon and its companions on the other. The existence of the hypothetical element fluorine was postulated in many well-investigated compounds as early as the beginning of the present century; yet, on account of its intense chemical activity, fluorine was not prepared as a free element until 1886, despite the numberless attempts which had been made to isolate it in the intervening period. Argon, on the other hand, owing to its absolute inertness, and to the fact of its occurrence along with the very inert nitrogen, led an unsuspected existence until 1894, although it was contained in enormous quantities in the atmosphere—a constant subject of investigation. The compounds of fluorine, then, were known long before the element itself,—compounds of argon are still wanting. Indeed, as has been pointed out (Sedgwick, "Argon and Newton," p. 2), the name element in the ordinary sense cannot properly be applied to argon and its companions at all, since that term implies the existence, or at least the possibility of existence, of compounds concerning which we are still in total ignorance. As yet there is no chemistry of argon.

The time, however, has now arrived when fluorine and its compounds can be brought under review so as to give a picture of the element in itself and in its combinations, which in main outlines, at least, may be looked upon as final. Prof. Moissan was obviously the man to execute this task; he has fortunately undertaken it, and the book before us gives the result of his labours. As evidence of the extent of the author's research, we may adduce the bibliography given as appendix, which occupies eighty-five pages, and contains references to about six hundred books and papers. These references are arranged alphabetically according to authors, and also chronologically, beginning with Agricola, 1558, and ending with the year 1899.

In the book itself the author's investigations have naturally the first place, and one of the chief points of interest is that M. Moissan not only gives us an account of his apparatus, experiments and results, but also of the leading thoughts which guided him from one experiment to another, until the culmination was reached in the liberation of the gaseous element. The student beginning research could not find a more stimulating record of failure and eventual success than that afforded in Chapter i., on the isolation of fluorine. Chapter ii. deals with the most recent apparatus for the production of fluorine by electrolysis. At a temperature of about $-80°$, attained by the evaporation of a mixture of solid carbonic acid and acetone, it is possible to use an electrolytic vessel of copper instead of platinum, provided that the hydrofluoric acid employed is free from water. This substitution brings elementary fluorine within the scope of any well-equipped chemical laboratory. Chapter iii. deals with the physical properties of fluorine, its liquefaction, and the action of the liquid on various substances. In